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METHOD FOR MANUFACTURING LIQUID CRYSTAL DISPLAY ELEMENT

[Abstract]

PROBLEM TO BE SOLVED: To improve the display quality of a liquid crystal display element by preventing vacuum space from remaining in a liquid crystal cell due to uneven spreading of a liquid crystal in a sealing step of the liquid crystal with a dripping method.

SOLUTION: A sealant 14 is applied on an array substrate 11. Subsequently the liquid crystal 17 is dripped and applied to the inside of a pixel area [A] surrounded by the sealant 14 like a thin film with a slit squeegee device 25. Then under the reduced pressure the array substrate 11 and a counter substrate 12 are stuck to each other. Subsequently the liquid crystal 17 is uniformly sealed in the liquid crystal cell without making the vacuum space remain therein by returning the

pressure to the atmospheric pressure.

[Claim(s)]

[Claim 1] A method for manufacturing a liquid crystal display element comprising:

a first process of applying a sealant for sealing a liquid crystal to one of a pair of substrates which are oppositely arranged to each other;

a second process of dropping the liquid crystal in a state of a thin film in an area surrounded by the sealant in one of the pair of substrates;

a third process of bonding the pair of substrates with the sealant such that a predetermined gap can be maintatined between the substrates under reduced pressure after the second process is completed; and

a fourth process of curing the sealant after the third process is completed.

[Claim 2] The method for manufacturing a liquid crystal display element according to claim 1, wherein the second process is performed using an applying device of an ink jet type.

[Claim 3] The method for manufacturing a liquid crystal display element according to claim 1, wherein the second process is performed using an applying device which is formed in a shape of a squeegee having a ditch which is formed in

a shape of a slit.

[Claim 4] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 3, wherein an amount of applying the liquid crystal in a state of a thin film is ±3% (of a predetermined amount of applying the liquid crystal).

[Claim 5] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 4, wherein a range of applying the liquid crystal in a state of a thin film in the second process is equally spaced with a predetermined width from an inner side of the sealant.

[Claim 6] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 5, wherein the sealant applied in the first process is an ultraviolet curing sealant.

[Claim 7] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 5, wherein the sealant applied in the first process is a heat curing sealant.

[Claim 8] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 5, wherein the sealant applied in the first process is a sealant that requires both of the ultraviolet curing and the heat curing

sealants.

[Claim 9] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 8, wherein the predetermined gap in the third process is maintained by spacers which are formed in a shape of a sphere and arranged separately between the pair of the substrates.

[Claim 10] The method for manufacturing a liquid crystal display element according to any one of claims 1 to 8, wherein the predetermined gap in the third process is maintained by spacers which are formed in a shape of a column and formed on one of the pair of the substrates using photolithograhpy process.

[Title of the Invention]

METHOD FOR MANUFACTURIG A LIQUID CRYSTAL DISPLAY ELEMENT

[Detailed Description of the Invention]

[Field of the Invention]

The present invention relates to a method for manufacturing a liquid crystal display element.

[Description of the Prior Art]

In a liquid crystal display element which is fabricated by sealing a liquid crystal between a pair of substrates having electrodes, as a method for sealing a liquid crystal in prior art, there have been applied an injection method wherein a pair of substrates are bonded to each other by a sealant, a liquid crystal cell is assembled, a liquid crystal is injected from a injection hole formed with a sealant, and then the injection hole is sealed by an adhesive or the like, and, as shown in Fig. 10, a dripping method wherein a seal pattern 2 having no injection hole with a sealant is formed on either one of the substrates 1, a predetermined liquid crystal 3 is dropped in a form of water drop on an area surrounded by the sealant, a spacer is interposed between the one substrate 1 and the other substrate 4, bonded to

each other under the reduced pressure such that a bubble does not remain in the liquid crystal cell, and then, the seal pattern 2 is cured.

[Problem to be Solved by the Invention]

In the injection method, since a liquid crystal was injected into a narrow injection hole in a substrate after the substrates are bonded and a liquid crystal cell was formed, there have been problems that a long time was required from the curing of a sealant to the completion of injection of a liquid crystal, and its productivity was significantly lowered. Furthermore, since the injection hole was sealed by the sealant after the liquid crystal was injected, there has been a problem that an unusual point was occurred in a liquid crystal display element near the injection hole whereby it became a cause of fine charcoal and the quality of display was deteriorated. In addition, in case that the adhesive property of an adhesive is poor, there has been a problem that a peeling was happened and bubble was generated upon sealing.

For this reason, in recent years, a method of sealing a liquid crystal according to a dropping method has been considered. The dropping method comprises, in the manufacturing process thereof, dropping a liquid crystal with water droplet on one of the two substrates, bonding the one substrate and a

substrate opposed thereto in vacuum, and returning the two substrates under the circumstance of atmospheric pressure. Consequently, since the liquid crystal dropped with water droplet may be spread in the liquid crystal cell by means of a difference of the pressure between inside and outside of the liquid crystal cell, the neighboring liquid crystal is contacted to each other and fill a vacuum space whereby the liquid crystal is uniformly sealed in the liquid crystal cell.

However, generally in the dropping method, since a difference of the pressure between inside and outside of the liquid crystal cell is big when the substrates are returned from a circumstance of vacuum to a circumstance of atmospheric pressure, the liquid crystal is easily spread but if the vacuum space in the liquid crystal cell is filled with the spread liquid crystal, a volume of vacuum in the liquid crystal cell will be reduced and a degree of vacuum will be decreased. Thus, since a difference of the pressure with atmospheric pressure is lowered, a force that the liquid crystal can be spread is gradually weakened. For this reason, a liquid crystal would not spread up to a farthest point that the neighboring liquid crystal can be contacted to each other, a phenomenon that a vacuum space still remains is occurred, and thus, a poor display space was produced. Thus, a problem that the uniform and good quality of display cannot be attained has arisen.

Accordingly, the present invention is intended to eliminate the above-

mentioned problem. It is an object to the present invention to provide a method for manufacturing a liquid crystal display element wherein, in a liquid crystal cell upon sealing of a liquid crystal by means of a dropping method, a vacuum space in which a liquid crystal is not present is not provided, and it is possible to attain the uniform and good quality of display over entire surfaces of the display area thereby enabling a sealing process of a liquid crystal to be realized by means of a dropping method by which a time of manufacturing a liquid crystal display element can be reduced.

[Means for Solving the Problem]

In order to solve the above-mentioned problem, the present invention provides a method for manufacturing a liquid crystal display element comprising: a first process of applying a sealant for sealing a liquid crystal to one of a pair of substrates which are oppositely arranged to each other; a second process of dropping the liquid crystal in a state of a thin film in an area surrounded by the sealant in one of the pair of substrates; a third process of bonding the pair of substrates with the sealant such that a predetermined gap between the substrates is maintained under reduced pressure after the second process is completed; and a fourth process of curing the sealant after the third process is completed.

According to the technical constitution, the present invention can prevent a

vacuum space from remaining in a liquid crystal cell upon sealing of a liquid crystal and attain the good quality of display thereby enabling a sealing of a liquid crystal to be realized with a dropping method. Thus, a time of manufacturing a liquid crystal display element can be reduced and an improvement in a production thereof can be achieved.

[Embodiment of the Invention]

The present invention will be described below with reference to a first embodiment shown in Figs. 1-4. Reference numeral 10 designates a liquid crystal display element, and the liquid crystal display element comprises an array substrate 11 and an opposing substrate 12 in which a pixel electrode (not shown) and an opposing electrode (not shown) are arranged, respectively. After performing rubbing treatment of each of oriented films 13 arranged on the substrates, the liquid crystal display element is manufactured by bonding the substrates with a sealant 14 made of, for example, an ultraviolet curing resin or the like so as to provide a predetermined gap therebetween by spacers 16, and sealing a liquid crystal in an area surrounded by the sealant 14.

Next, a method for manufacturing the liquid crystal display element 10 will be described. For example, after forming an array substrate 11 having a pixel area [A] of 13.3 inches having a pixel electrode and an opposing substrate 12

having an opposing electrode, for example, a polyimide is applied on each of the substrates, an oriented film 13 is heated at high temperature so as to have a thickness of 1,000 Å by performing a heat treatment at 250°C for 30 minutes, and rubbing treatment is performed in a predetermined direction with a rubbing cloth after cooling.

Then, a ultraviolet curing sealant 14 made from acryl or the like is applied on one of the substrates, for example, by a syringe so as to surround a pixel area [A] within a cross sectional area of a range of 5,000 to 10,000μm^2 in an array substrate 11, and a bank formed in a shape of a frame is provided. Meanwhile, for example, the spacers 16 with Φ 5μm for maintaining a gap between the array substrate 11 and the opposing substrate 12 with a regular gap width are arranged in 200 / mm^2 in the opposing substrate 12.

Then, a liquid crystal 17 is dropped and applied in a state of a thin film on the pixel area [A] surround by the sealant 14 in the array substrate 11. The dropping application is performed, for example, by a squeegee 26 where a slit (not shown) is arranged by a slit squeegee device 25 shown in Fig. 3. In the squeegee 26, the slit has a width of 180 mm and a hole 27 has a width of 10 μm. The liquid crystal is applied to a liquid crystal inlet 28 in a constant pressure, a gap between the array substrate 11 and a lower end of the squeegee 26 is measured by a gap

sensor 30 and the gap is controlled to be constant.

When the liquid crystal 17 is dropped, the array substrate 11 is arranged on a XY stage, which is not shown on the drawings, and the liquid crystal is discharged to set a liquid discharge rate from the squeegee 26 to 0.03 cm^3/sec and an injection velocity of the XY stage to 2 cm/sec. As a result, the thickness of film of a liquid crystal 17 to be dropped on the array substrate 11 is about 6.6 μm. The thickness of film of a liquid crystal 17 in a state of a thin film is about ±2%.

A total amount of the liquid crystal to be dropped is determined according to a dimension of the pixel area [A] and the gap between the array substrate 11 and the opposing substrate 12 constituting the liquid crystal cell. For example, an objective value of a total amount for applying the liquid crystal 17 is 280 ml when the pixel area [A] is 13.3 inches and the gap between the two substrates is 5 μm. In this case, a total amount of the liquid crystal dropped substantially is ideal to be set within ±3% of the objective value.

If a total amount of the liquid crystal to be substantially dropped is more than 3% of the objective value, when the array substrate 11 and the opposing substrate 12 are bonded under a state of vacuum and returned to an atmospheric pressure, and then, the two substrates 11, 12 are compressed so as to provide a prescribed gap between the two substrates, the liquid crystal 17 will be caused to

be filled in the liquid cell surrounded by the sealant 14 before reaching the height of the spacer 16. Moreover, since the sealant 14 is still not cured, the liquid crystal 17 breaks down the bank formed by the sealant 14 and overflows to the outside. For this reason, when the sealant 14 is cured, the assembling strength of the liquid crystal cell is considerably deteriorated due to a poor adhesion of a portion where the liquid crystal 17 overflows and thus, its reliability is lowered.

On the other hand, if a total amount of the liquid crystal to be substantially dropped is less than 3% of the objective value, when the array substrate 11 and the opposing substrate 12 is bonded under a state of vacuum and returned to an atmospheric pressure, and then, the two substrates 11, 12 are compressed so as to provide a prescribed gap between the two substrates, a liquid crystal to be filled in an inner space of the liquid crystal cell surrounded by the sealant 14 will be not sufficient. As a result, a vacuum space, which is not filled with the liquid crystal 17 between the two substrates 11, 13, remains in the pixel area [A] of the liquid crystal display element 10 finally completed, and thus, a remarkable display poorness may be caused.

Since a thickness of a film is not stable in an end portion of a periphery of the liquid crystal 17 which is dropped and applied in a state of a thinner film, and the film is slowly cut, the liquid crystal 17 is dropped and applied in a state of a thin

film such that an end of the liquid crystal is positioned to have a distance of 10 mm from the sealant 14 formed on the array substrate 11.

Consequently, a thickness of the thin film is about 6.6 μm, a size of the thin film is about 183 mm in a vertical direction and about 230 mm in a horizontal direction.

Like this, the liquid crystal 17 is dropped on the array substrate 11 in a state of a thin film, the two substrates are bonded by an assembling apparatus 40 under a condition that the spacers 16 are arranged apart to each other, and then, the liquid crystal display element 10 is assembled. That is, in a vacuum chamber at 1 Torr, the array substrate 11 is absorbed on a lower stage 42 which is adjustable in XYZ directions, the opposing substrate 12 is absorbed on a upper stage 43 which is adjustable in XYZ directions, and the upper and lower stages 42, 43 are moved and aligned under a condition that the two substrates 11, 12 are spaced apart to each other. Next, the two substrates 11, 12 are compressed under the pressure of 40 kgf, and are bonded to each other.

Thereafter, if the two bonded substrates 11, 12 are returned to the atmosphere, the liquid crystal 17 is spread and filled in a vacuum space of the liquid crystal cell due to a difference of the pressure between inside and outside of the liquid crystal cell. Then, the two substrates 11, 12 are compressed at about 300

kgf so that the prescribed width of the gap therebetween is 5 μm, the sealant 14 is cured with irradiating ultraviolet ray with about 3,000 mJ/cm^2 by an ultraviolet irradiating lamp 42a equipped in the lower stage 42 for curing the sealant 14, and the liquid crystal display element 10 is accomplished.

According to the manufacturing method, in sealing the liquid crystal by means of a dropping method, when the array substrate 11 and the opposing substrate 12 are bonded under the reduced pressure and returned to atmosphere, the vacuum space does not remain in the liquid crystal cell and the liquid crystal 17 is uniformly spread in the liquid crystal cell, thereby obtaining the liquid crystal display element 10 having a good quality of display. Therefore, this enables a sealing of a liquid crystal by means of a dropping method to be realized whereby a time of manufacturing a liquid crystal display element can be reduced and an improvement in the production thereof can be achieved.

Next, the present invention will be described below with reference to a second embodiment shown in Fig. 5. The second embodiment illustrates performance of a dropping of the liquid crystal to the array substrate by a method of ink jet as compared with the first embodiment. Since the other points thereof are equal to those of the first embodiment, the same reference numerals are used with respect to the same elements and their descriptions will be omitted.

In the present embodiment, a dropping application of the liquid crystal 17 in a state of a thin film into a pixel area [A] surround by the sealant 14 in the array substrate 11 is carried out by a liquid crystal applying head 18, which is composed of a type of an ink jet. The liquid crystal applying head 18 is constructed such that a piezo element 21 in a nozzle block 20 is fixed to an upper portion of a spring 22 which is formed in a shape of a plate spring. The liquid crystal 17 is injected into a liquid crystal inlet 23 positioned in a space below the spring 22 in the nozzle block 20, and is discharged to a nozzle hole 24 by vibrating the piezo element 21.

In the liquid crystal applying head 18 used above, a diameter of the nozzle hole 24 is 50 µm, 70 lines having a pitch of 200µm are provided, and a width of application is about 14 mm. The liquid crystal 17 can be sprayed by applying a voltage of 1,000 mV and a frequency of 50 Hz to the piezo element 21 of the liquid crystal applying head 18. Upon dropping of the liquid crystal 17, the array substrate 11 applied with the sealant 14 is arranged on a XY stage, which is not shown in the drawings, the liquid crystal 17 is sprayed from the liquid crystal applying head 18 while the XY stage is injected, and a dropping application of the liquid crystal 17 in a state of a thin film on the array substrate 11 is carried out. If the injection velocity of the XY stage is, for example, 50 mm/sec, a thickness of film of the liquid crystal 17 to be dropped on the array substrate 11 is about 6.7 µm, and thus, the desired dropping amount of the liquid crystal 17 can be obtained.

Like the first embodiment, if the array substrate 11 and the opposing substrate 12 are compressed and bonded under the pressure of 40 kgf, and the two bonded substrates 11, 12 are returned to the atmosphere, in a vacuum chamber at 1 Torr by means of the assembling device 40, the liquid crystal 17 can be spread without leaving a vacuum space due to a difference of the pressure between inside and outside of the liquid crystal cell. Then, the two substrates 11, 12 are compressed at about 300 kgf, the sealant 14 is cured by irradiating ultraviolet ray with about 3,000 mJ/cm^2, and the liquid crystal display element 10 is accomplished.

According to the manufacturing method, like the first embodiment, in sealing the liquid crystal by means of a dropping method, the vacuum space does not remain in the liquid crystal cell and the liquid crystal 17 is uniformly spread in the liquid crystal cell, thereby obtaining the liquid crystal display element 10 having a good quality of display. Therefore, this enables a sealing of a liquid crystal by means of a dropping method to be realized.

Next, the present invention will be described with reference to a third embodiment shown in Figs. 6-8. The third embodiment illustrates forming and bonding of the array substrate and the opposing substrate having two surfaces on the glass substrate, respectively, as compared with the first embodiment. When

the array substrate and the opposing substrate are bonded to each other, a plurality of additional pressures is simultaneously applied to the same plane of the substrate. Since the other points thereof are equal to those of the first embodiment, the same reference numerals are used with respect to the same elements and their descriptions will be omitted.

In the third embodiment, a film forming method and a photolithography method are repeated, for example, on a mother glass substrate 51 of 300 x 300 x 0.7 mm, and two array substrates 52 having pixel electrodes (not shown) with a matrix field of 320 x 240 dot are formed while two opposing substrates 54 (not shown) formed in a shape of a plane are formed on a mother glass substrate 51 of 300 x 300 x 0.7 mm. In addition, for example, a polyimide is applied on the array substrate 52 and the opposing substrate 54, an oriented film (not shown) is baked at high temperature so as to have a thickness of 1,000 Å by performing a heat treatment at 250°C for 30 minutes, and a rubbing treatment is performed after cooling.

Then, on one of the substrates, for example, on the array substrate 52, an ultraviolet curing sealant 56 made from, for example, acryl is applied by, for example, a syringe to surround a pixel area [B] and constitutes a bank having a shape of a frame. Meanwhile, on the opposing substrate 54, for example, spacers

16 with Φ 5μm for maintaining a prescribed gap between the array substrate 52 and the opposing substrate 54 by a regular gap width are arranged with 200 / mm^2.

Next, a squeegee 26 is used as in the first embodiment, a liquid crystal 57 is dropped and applied on the pixel area [B] surrounded by a sealant 56 in the array substrate 52 in a state of a thin film having a thickness of about 6.6 μm. Meanwhile, the two mother glass substrates 51, 53 are bonded by an assembling apparatus 31 shown in Fig. 7 under a condition that spacers 16 are arranged apart in the opposing substrate 54, the sealant 56 is cured, the substrates are taken off by one surface, and the liquid crystal display element 58 is assembled.

The assembling apparatus 31 includes a lower stage 33 which is adjustable in XYZ directions in a vacuum chamber and absorbs the mother glass substrate 51 in vacuum, and an upper stage 34 which is adjustable in XYZ directions in a vacuum chamber and absorbs the mother glass substrate 53 in vacuum. An ultraviolet irradiating lamp 36 is equipped in the lower stage 33.

The upper stage 34 is comprised of a double fame structure including a first range of compression stage 37 for pressing an area corresponding to the sealant 56, and a second range of compression stage 38 for pressing an area defining a periphery of the first range of compression stage 37 and positioned at an outside of the sealant 56. The first range of compression stage 37 and the second range of

compression stage 38 may be pressed by different pressures, respectively. Consequently, upon being pressed, the mother glass substrates 51, 53 are constituted such that both the pressing by the first range of compression stage 37 and the pressing by the second range of compression stage 38 are simultaneously applied.

When the liquid crystal display element 58 is assembled, in a vacuum chamber 32 at 1 Torr, the mother glass substrate 51 is absorbed in vacuum on a lower stage 33 while the mother glass substrate 53 is absorbed in vacuum on an upper stage 34, and the upper and lower stages 33, 34 are moved and aligned under a condition that the two substrates 51, 53 are spaced apart to each other. Thereafter, when the two substrates 51, 53 are bonded and the bonded substrates are returned to the atmosphere, the liquid crystal 57 is spread and filled in a vacuum space of the liquid crystal cell due to a difference of the pressure between inside and outside of the liquid crystal cell.

Then, for example, an area of the sealant 56 is pressed with a pressure of 0.5 kg/cm^2 by the first range of compression stage 37, an area of the sealant 56 is pressed with a pressure of 1 kg/cm^2 by the second range of compression stage 38, an ultraviolet ray is irradiated in 2000 mJ/ cm^2 by a ultraviolet irradiating lamp 36 and the sealant 56 is cured. The liquid crystal display element 58 is accomplished

so that the mother glass substrates 51, 53 are cut in a half thereof and separated from each other to provide a mother glass substrate 58 having one surface, respectively.

As a result, phenomena that peripheral portions of the substrates 62, 63 are bent due to a difference of the atmospheric pressure between inside and outside of a sealant 61 of the liquid crystal display element 60, irregularity of the gap is occurred, and the quality of display is significantly lowered, can be solved.

According to the manufacturing method, as in the first embodiment, in sealing the liquid crystal by means of a dropping method, the vacuum space does not remain in the liquid crystal cell and the liquid crystal 17 is uniformly spread in the liquid crystal cell, thereby improving the quality of display of the liquid crystal display element 10 and thus, enabling the sealing of the liquid crystal by means of the dropping method to be realized. When the sealant 56 is cured, since a pressure of an outside of the sealant 56 may be greatly increased as compared with an area of the sealant 56, a flexion is not happened in the liquid crystal cell regardless of a difference of the pressure between inside and outside of the sealant 56, and can solve the irregularity of the gap around the periphery of the liquid crystal cell which has been caused in the prior art. Accordingly, a uniform gap can be obtained over the entire surface of a liquid crystal display element 58 and thus,

improve a quality of display of a liquid crystal display element.

The present invention is not limited to the embodiments described above, and various modifications may be effected without departing from the scope of the invention. For example, the present invention is applicable to any method by which a liquid crystal can be dropped and applied in a state of a thin film on a display area, any thickness of a liquid crystal may be suitably selected if a required amount of the liquid crystal can be obtained, and a degree of vacuum in a vacuum chamber during an assembling process may be also suitably selected as required. Further, a sealant is not limited to those cured by an ultraviolet irradiation, and may be selected variously from those cured by a heat, an ultraviolet irradiation and/or both of them.

Furthermore, the present invention is applicable to any of construction of the liquid crystal display element, a color filter layer may be formed on an array substrate and an opposing substrate, or a column spacer 67 may be formed on the array substrate 66 as in a modified embodiment shown in Fig. 9 to maintain a gap between the array substrate and the opposing substrate 68 with a desired width thereof. Further, any number of surfaces of the liquid crystal display element formed simultaneously on the mother glass substrate is also selectable.

[Effect of the Invention]

As described above, according to the present invention, in a method for sealing a liquid crystal according to the dropping method that is capable of reducing a time of manufacture, the present invention can prevent a vacuum space from remaining in a liquid crystal cell after sealing of a liquid crystal and fill a liquid crystal uniformly on an overall surface of a liquid crystal cell thereby improving a quality of display of a liquid crystal display element and it is possible to seal a liquid crystal by a dropping method.

[Description of Drawings]

Fig. 1 is an exploded schematic illustration showing a method for sealing a liquid crystal according to a first embodiment of the present invention.

Fig. 2 is a schematic illustration showing a liquid crystal display element of the first embodiment of the present invention.

Fig. 3 is a schematic structural illustration showing a slit squeegee device of the first embodiment of the present invention.

Fig. 4 is a schematic structural illustration showing an assembling apparatus of the first embodiment of the present invention.

Fig. 5 is a schematic structural illustration showing a liquid crystal applying head of a second embodiment of the present invention.

Fig. 6 is an exploded schematic illustration showing a liquid crystal display element on a mother glass substrate of a third embodiment of the present invention.

Fig. 7 is a schematic structural illustration showing an assembling apparatus of the third embodiment of the present invention.

Fig. 8 is a schematic illustration showing a flexion phenomenon of a plate glass substrate happened in a prior art in the third embodiment of the present

invention.

Fig. 9 is a schematic illustration showing a liquid crystal display element of a modified embodiment of the present invention.

Fig. 10 is an exploded schematic illustration showing a method for sealing a liquid crystal according to a dropping method of a prior art.